UNCLASSIFIED

AD NUMBER
AD871047
NEW LIMITATION CHANGE
TO **Approved for public release, distribution unlimited**
FROM **Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; DEC 1962. Other requests shall be referred to Naval Oceanographic Office, Code 4300, Washington, DC 20390.**
AUTHORITY
USNOO notice, 25 Jan 1971

THIS PAGE IS UNCLASSIFIED

AD871047

INFORMAL MANUSCRIPT REPORT

NO. 0-71-62

TITLE

[illegible] WEYMOUTH FORE RIVER DYE DISPERSAL
[illegible] MASSACHUSETTS

STATEMENT #4 UNCLASSIFIED

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of NAVAL OCEANOGRAPHIC OFFICE, Code 4300, Washington, D.C. 20390.

AUTHOR

[illegible]
[illegible]
[illegible]
[illegible] ANALYSIS DIVISION

DATE

[illegible]MBER 1962

[redacted]

This manuscript has a limited distribution, therefore in citing it in a bibliography, the reference should be followed by the phrase UNPUBLISHED MANUSCRIPT.

MARINE SCIENCES DEPARTMENT
U. S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON 25, D.C.

ABSTRACT

A dye tracer study was conducted in the Weymouth Fore River, Quincy, Massachusetts for the purpose of determining the time required to remove or reduce to permissible concentrations any contaminating material released as a point source in the river. The test consisted of releasing a quantity of Rhodamine-B dye into the water and monitoring the dilution and dispersion of the dye by continuous fluorometric analysis of the water and by aerial photographs of the dye patch. Results of the test are compared with theoretical flushing times computed previously.

ACKNOWLEDGMENTS

Boat services were provided by the U. S. Naval Base, Boston, Massachusetts, and logistic support for the test was provided by the U. S. Naval Ammunition Depot, Hingham, Massachusetts. Photographic and helicopter services were provided by the U. S. Naval Air Station, Lakehurst, New Jersey. Without this valuable assistance the test could not have been successfully conducted.

The following personnel of the U. S. Naval Oceanographic Office assisted in the field work:

Mr. J. J. Gallagher, Oceanographic Analysis Division

Mr. R. L. Magan, Marine Surveys Division

CONTENTS

LIST OF FIGURES

LIST OF TABLES

FIELD REPORT, WEYMOUTH FORE RIVER
DYE DISPERSAL TEST,
QUINCY, MASSACHUSETTS

I. INTRODUCTION

The Oceanographic Office has completed theoretical studies of the flushing characteristics of 17 harbors and estuaries in the United States. In order to evaluate the results of these theoretical studies, prototype field dye dispersal tests were planned for several of the harbors and estuaries exhibiting different physical characteristics. One of these, the Weymouth Fore River at Quincy, Massachusetts, was selected because the theoretical report was based on a very limited amount of data.

In an estuary such as the Weymouth Fore River (Figure 1), three principal methods can be used for predicting the dilution and dispersion of a contaminant. These are discussed in detail in reference (1) of the bibliography. Briefly, these methods are:

a. Tidal prism method -- Basically, in this method the rate of dilution and dispersion of a contaminant depends on the total volume of water transported seaward through a given segment of the estuary defined by the average excursion of a water particle on the flood current.

b. Diffusion equation method -- When a coefficient of diffusion can be determined, the rate of dilution and dispersion of a contaminant by the natural turbulence in a water body may be predicted.

c. Advection method -- The movement of a contaminant released in a tidal estuary may be predicted from a knowledge of the tidal currents in the estuary.

The results of the Weymouth Fore River dye dispersion test are reported herein, and comparisons are made, when possible, with the theoretical results in an attemothto determine the validity of the above methods as applied to this area.

II. TEST PROCEDURES AND DATA

A. General test procedures -- The general test procedures were similar to those followed during dye dispersion tests conducted previously in Mare Island Strait, California (2) and Pearl Harbor, Hawaii (3). These consisted of releasing a quantity of a fluorescent dye (Rhodamine-B or fluorescein) into the water and monitoring its dilution and dispersion until the concentration decreased below the threshold of the sampling equipment or until other factors such as weather conditions, ship traffic, etc. restricted monitoring. Sampling equipment consisted of a Turner Model III Fluorometer equipped with a continuous flow sample compartment and attached recorder. This equipment is capable of detecting, under optimum conditions, concentrations as low as two parts of dye per hundred billion parts of water. The Fluorometer and attached recorder are compact portable instruments that can be mounted easily aboard a small vessel for continuous analysis of water samples as the boat traverses the dye patch in a harbor or estuary. Water from selected depths is pumped through the

Fluorometer which continuously measures the dye content of the water, thus providing a comprehensive record of the dilution and dispersion of the dye throughout a harbor or estuary.

Sampling procedure during this test was similar to that followed during previous dye dispersal tests conducted by this Office. Throughout the part of the test when the dye patch was plainly visible, the procedure consisted of traversing the dye patch at specified time intervals to determine the spatial distribution of dye within the patch. Sampling throughout the test was limited almost entirely to a depth of approximately 6 feet because of the large regions of shallow water. However, in the deeper waters of the channel and harbor proper, the sampling hose was periodically lowered to the bottom in order to determine the depth to which the dye had penetrated.

To supplement the data obtained by water sampling, aerial photographs of the dye patch were taken at 30-minute intervals after dye release except for two photographs taken 10 and 15 minutes after release. Photographs were discontinued at 1230 (3 hours 15 minutes after release) when the dye patch became too diffuse for aerial photography. The scale of the photographs varied considerably because they were taken at various camera angles from different altitudes. To present a comprehensive picture of the movement of the dye patch in the river, the outline of the dye patch determined from each of the photographs was reduced to the same scale and reproduced in Figures 2 through 8.

After 113C, only the leading edge of the dye patch is shown because the trailing edge had become so diffuse that a well-defined outline could no longer be determined.

After the dye patch was no longer visible, the sampling procedure consisted of designating a number of stations throughout the test area (Figure 1) and measuring the dye concentration at various times at each of the stations encompassed by the dye.

B. Preliminary survey -- On 12 September 1961, several sampling runs were made throughout the Weymouth Fore River, Town River Bay, Hingham Bay, and Hull Bay to determine the background fluorescence of the water. The background, which consists of the natural fluorescence of the water and false readings of fluorescence caused by turbid water, remained relatively constant throughout the area. However, in shallow water, where turbid water was prevalent, the background varied considerably and introduced some error into the final results of the test, although corrections were made whenever possible to reduce the error to a minimum.

C. Test data -- The dye dispersion test was conducted in the Weymouth Fore River during the period 13 through 20 September 1961. On 13 September, approximately 30 gallons of a solution containing 100 lb. of Rhodamine-B dye were released as a point source in the Weymouth Fore River at the point indicated in Figure 2. The dye solution (initial concentration 0.40 g/cc) was released at 0915 EDT, approximately one hour after slack before flood. Immediately after release, the dye was carried southward in the

Weymouth Fore River by the flood current. The dye was transported into the shallow embayment south of North Weymouth and southward through the Weymouth Fore River as far as East Braintree. The major part of the dye remained entrapped in this general region (Figure 9) and acted as a continuous source, with a slow net outward flow of dye. The progression of the dye patch from the time of release until the patch was no longer visible is indicated in Figures 2 through 8. These figures were constructed primarily from the aerial photographs of the dye patch.

From 13 through 20 September, dye concentrations were measured at various time intervals at as many of the sampling stations as possible. The dye concentrations for various times after release at selected stations are listed in Table 1. Measurements of dye concentration also were made at stations other than those listed and, in addition, concentrations were measured continuously while transiting between stations. These data are not listed because the data for the stations indicated in the table were considered sufficient to present a general picture of the dye distribution.

The measurements of dye concentration at the 6-foot depth were plotted on a chart of the area, and isopleths of dye concentration were drawn; Figures 10 through 12 show the distribution of dye determined by this method. Isopleths were not drawn for times greater than 126 hours after release because the spatial

concentration of dye indicated little variation throughout the test area.

The actual configuration of the dye patch at all times was more irregular than shown in the figures, and smooth isopleths were drawn to present a general description of the distribution and movement of the dye. Measurements of dye concentrations at all stations and between stations were considered in the construction of the isopleths, although the data are not listed in the tables. Lowest concentration indicated in the figures is 1×10^{-10} g/cc; lower concentrations were measured, but the reliability of the data decreased rapidly below this value because slight background variations introduce a significant error at these low concentrations.

The time required to complete a circuit of the dye patch and measure the dye concentration at each station within the patch varied considerably. The time elapsed depended on the areal extent of the dye patch and the number of delays caused by equipment maintenance and ship traffic. To obtain a completely accurate picture of the dye distribution throughout the test area, the measurements would have to be made simultaneously at each station. However, the error introduced by nonsynoptic sampling was considered negligible because of the slow change in the dye distribution during the latter part of the test.

Figures 10 through 12 clearly indicate the region in which the dye was entrapped. The figures also show that the dye moved slowly out of the region of entrapment through the Weymouth Fore

River and into Hingham Bay. The net outflow of the dye continued throughout the test period, and by 20 September, the final day of the test, concentrations had been reduced to values near background level.

Because of the low dye concentrations in Hingham Bay, the direction of movement of the dye in the bay was difficult to determine accurately. However, from the limited amount of data obtained, a net outflow through Nantasket Gut and West Gut is indicated. The major outflow through Nantasket Gut tends to verify the resultant current chart in the theoretical report.

The dye also began moving into Town River Bay with the flood following the first ebb after release as predicted in the theoretical report; because of approaching darkness sampling was discontinued shortly after the flood began. From the data obtained it is estimated that a maximum dye concentration of approximately 1.0 1.0 x 10^{-7} g/cc was reached in Town River Bay at about 15 hours after release. The dye remained in Town River Bay throughout the test, with a net outflow into the Weymouth Fore River which proceeded at about the same rate as the outflow from the major region of entrapment south of North Weymouth.

The decrease in concentration of the dye with time is shown in Figure 13. The curve represents the highest concentration of dye measured at a depth of 6 feet at various times after release, regardless of location. The most significant feature of the curve is the rapid decrease in concentration during the first two hours after release which may be attributed to the initial dilution by

the receiving waters. Thereafter, concentrations decreased at a much slower rate until they reached the background level. Figure 13 also shows the time-concentration curve for Town River Bay, which indicates the estimated peak concentration and the observed decrease in concentration.

The test results indicate the behavior of a contaminant released as a point source near slack before flood, one of the worst possible times for a contaminant release in the Weymouth Fore River. A release at slack before ebb or during the ebb would result in an outward (northeasterly) transport of the contaminant. The contaminant would be carried into Hingham and Hull Bays, and part would be transported out of the bays through Nantasket and West Gut. On the following flood, the direction of flow would reverse and the contaminant, greatly diluted by the volume of water in the river and bays, would be carried back into the Weymouth Fore River and Town River Bay where it would follow essentially the same course as that described in this dye test. However, concentrations would be much lower, entrapment would not be as great, and the flushing rate would be more rapid than for a contaminant released at slack before flood or during the flood. A dye test to describe the behavior of a contaminant released at slack before ebb had been planned, but inclement weather forced a cancellation of the test.

III. COMPARISON OF THEORETICAL AND TEST RESULTS

The principal aim of the test was to compare theoretical and observed dilution and dispersion of a contaminant in the Weymouth Fore River.

A. Modified tidal prism method -- In the theoretical study of the Weymouth Fore River, the modified tidal prism method was applied to the section of the Weymouth Fore River extending from East Braintree to a line connecting Houghs Neck and Lower Neck (Figure 1). However, only the region from East Braintree to a line connecting Shipyard Point with King Cove (Figure 1) was used in the comparison because the observed data are most reliable for this region.

One of the basic assumptions of the tidal prism theory is that the contaminating material must be distributed uniformly both horizontally and vertically throughout the estuary. Thus, valid comparison of the predicted curve and the test curve cannot be made until the dye is uniformly distributed throughout the specified area. During this test, a uniform distribution of dye throughout the area was closely approached at 6 hours after release.

The observed curve is compared with the predicted curve in Figure 13. Only the portions of the curves beyond 6 hours after release are considered in the comparison. The curves show fairly close agreement, the observed concentrations being approximately one order of magnitude greater than the predicted concentrations. This difference in concentrations can be attributed in part to the lack of uniform mixing of the dye throughout the specified area. The slopes of the curves are essentially the same, indicating a very close agreement in the observed and predicted rate of decrease in the concentrations throughout the area.

To simplify the test results and make them applicable to

other amounts of a dissolved contaminant released in the Weymouth Fore River, a set of empirical dilution factors (Table 2) has been computed. They were derived primarily from the curves in Figure 13 and can be used to estimate the peak concentrations in the river when a known amount of a contaminant is released. The dilution factors, when multiplied by the amount of the contaminating material released, will give the peak concentration at the time indicated. The dilution factors may be used for a contaminant released during any phase of the tidal currents (flood or ebb); however, the concentrations for a release during ebb are overestimated, especially for times greater than 4 hours after release.

B. Diffusion equation and advection methods -- Data obtained during this test were insufficient to determine the rate of dispersion and dilution of a contaminant in the Weymouth Fore River by application of these methods.

IV. CONCLUSIONS

The results of the dye tests describe the behavior of a contaminant released near slack before flood as a point source in the Weymouth Fore River for a given set of conditions (location of release point, river discharge, strength and duration of the flood current, etc.). Release of a contaminant under any other conditions would necessarily alter these results. However, the following conclusions derived from results of the test should generally apply under most conditions for release at slack before flood or shortly after flood begins.

A. For the first 6-12 hours after release, the modified

tidal prism method underestimates the rate of decrease in concentration because it is based on the assumption that the contaminant is initially distributed evenly throughout the section of the river under consideration.

B. If mixing of the contaminant throughout the specified area is complete (6-12 hours after release), the modified tidal prism method allows prediction of contamination concentrations which are accurate within one order of magnitude of the actual concentrations.

C. Decrease in concentration of a contaminant by dilution is very rapid during the first few hours after release; thereafter, decrease with time proceeds at a much slower rate and is due largely to natural flushing processes. Thus, if the mass of a contaminant introduced into the river is so large that dispersion and dilution during the first few hours (6-12) do not reduce the concentration below maximum permissible levels, the concentrations will remain above permissible levels for at least 48 hours and will extend over a large region of the river.

D. Entrapment of high concentrations of a contaminant released in the Weymouth Fore River may be expected in the region south of North Weymouth. The soluble and suspended portions of the contaminant will be slowly transported out of the region; however, the sediments in the widespread mudflats may become contaminated by settling and adsorption of the dye or other substance.

E. Town River Bay will remain free of the contaminant until the next flood following a release during flood or ebb. During the

flood the contaminant will be carried into the bay. However, concentration of the contaminant will be considerably lower and entrapment less extensive than in the region south of North Weymouth. Again, the sediments in the mudflats may become contaminated by adsorption and settling.

F. For a contaminant released at slack before ebb or during the ebb, it is expected that concentrations generally will be much lower, entrapment would not be as great, and the flushing rate would be more rapid than for a contaminant released at slack before or during flood.

V. BIBLIOGRAPHY

1. CLINE, C. H., and FISHER, L. J. "Flushing and Dispersal of Contaminants in Tidal Waters with Applications to the James River," U. S. Navy Hydrographic Office, Informal Oceanographic Manuscript 10-60. 42 p. July 1959. (Unpublished manuscript).

2. FISHER, L. J. "Field Report, Mare Island Strait Dye Dispersal Tests," U. S. Navy Hydrographic Office, Informal Oceanographic Manuscript 0-26-62. 40 p. April 1962. (Unpublished manuscript).

3. FISHER, L. J. "Field Report, Pearl Harbor Dye Dispersal Tests," U. S. Navy Hydrographic Office, Informal Oceanographic Manuscript 102-61 Revised. 62 p. July 1961. (Unpublished manuscript) CONFIDENTIAL.

4. RIDLEY, EDWARD L., and OSTERICHER, CHARLES JR. "Flushing Study of Weymouth Fore River, Quincy, Massachusetts," U. S. Navy Hydrographic Office, Informal Oceanographic Manuscript 31-60. 16 p. July 1960. (Unpublished manuscript)

5. U. S. COAST and GEODETIC SURVEY. "Tidal Current Tables Atlantic Coast of North America, 1961." Washington, D. C. May 1960.

TABLE

DYE CONCENTRATIONS (g/cc) MEASURED AT SELECTED STATIONS AT VARIOUS TIMES AFTER RELEASE

HOURS AFTER RELEASE

Station Number	0.5	1.25	1.75	3.25	4.50	5.50
1	4.0×10^{-6}	3.1×10^{-7}	5.0×10^{-8}	5.6×10^{-10}	7.0×10^{-9}	1.2×10^{-7}
2	4.5×10^{-6}	1.3×10^{-6}	2.6×10^{-7}	7.6×10^{-8}		
3				2.2×10^{-7}	2.3×10^{-8}	6.2×10^{-8}
4					3.8×10^{-7}	1.3×10^{-7}
5			4.3×10^{-7}	5.6×10^{-7}	3.6×10^{-7}	6.9×10^{-8}
6						
7			9.2×10^{-7}	6.8×10^{-7}	1.3×10^{-7}	4.8×10^{-8}
8					5.2×10^{-7}	2.8×10^{-7}
9				4.4×10^{-7}		5.2×10^{-7}
10				Backgroun	3.8×10^{-7}	2.4×10^{-7}
11						1.3×10^{-8}
12						6.2×10^{-8}
13						
14						6.2×10^{-8}
15						5.4×10^{-7}
16						3.4×10^{-9}
17				Background	Background	
18					Background	
19					Background	
20					Background	
21						
22						

TABLE 1 cont'd

Station Number	6.00	7.50	24	25	30	122
1	1.7×10^{-7}	1.6×10^{-7}	6.0×10^{-8}	3.6×10^{-8}	2.0×10^{-8}	1.7×10^{-9}
2		1.5×10^{-7}		7.6×10^{-9}		
3	1.0×10^{-7}	1.3×10^{-7}	1.1×10^{-7}	3.2×10^{-8}	1.0×10^{-8}	
4	2.0×10^{-7}	1.1×10^{-7}		8.0×10^{-8}	5.4×10^{-8}	
5	1.2×10^{-7}	2.6×10^{-7}	8.6×10^{-8}	3.9×10^{-8}	5.0x10-8	3.1x10-9
6	2.1×10^{-7}		1.0×10^{-7}			
7	2.6×10^{-7}	4.0×10^{-7}		9.3×10^{-8}	3.3×10^{-8}	
8	1.5×10^{-7}	2.5×10^{-7}		6.8×10^{-8}	3.2×10^{-8}	
9		7.2×10^{-8}		7.4×10^{-8}	8.7×10^{-8}	
10	9.8×10^{-8}	1.0×10^{-7}			9.2×10^{-8}	
11	4.3×10^{-9}					
12	2.8×10^{-8}				5.6×10^{-8}	
13	1.0×10^{-8}					
14	7.6×10^{-8}					
15	1.4×10^{-7}				6.2×10^{-8}	
16	3.6x10-8	3.7×10^{-8}	7.7×10^{-8}			
17		1.4×10^{-7}	6.5×10^{-8}		3.1×10^{-8}	1.0×10^{-9}
18			6.8×10^{-8}		2.0×10^{-8}	2.3×10^{-9}
19			8.0×10^{-8}		3.7×10^{-8}	2.3×10^{-9}
20			2.0×10^{-8}		3.7×10^{-8}	2.3×10^{-9}
21			4.0×10^{-9}		2.3×10^{-8}	2.3×10^{-9}
22			Background		1.4×10^{-8}	

TABLE 1 cont'd

Station Number	6.00	7.50	24	25	30	122
23			Background		1.3×10^{-8}	
24						
25	8.2×10^{-9}	1.2×10^{-7}	7.3×10^{-8}	3.6×10^{-8}	1.3×10^{-8}	8.0×10^{-10}
26	9.2×10^{-9}	4.5×10^{-8}	6.8×10^{-8}			
27	Background	5.0×10^{-8}	5.8×10^{-8}	3.1×10^{-8}	1.3×10^{-8}	1.7×10^{-9}
28		4.3×10^{-8}	6.0×10^{-8}	3.3×10^{-8}	1.1×10^{-8}	8.0×10^{-10}
29		1.7×10^{-8}	5.6×10^{-8}	1.3×10^{-8}	3.1×10^{-9}	8.0×10^{-10}
30		6.0×10^{-10}	4.5×10^{-8}	1.2×10^{-7}	5.4×10^{-9}	
31		Background	2.3×10^{-8}	6.3×10^{-9}	7.9×10^{-9}	5.6×10^{-10}
32				Background	Background	5.6×10^{-10}
33					Background	3.5×10^{-10}
34				Background	Background	1.5×10^{-9}
35						
36				Background		
37						8.4×10^{-10}
38						
39						
40						
41						
42						
43						
44						Background

TABLE 1 cont'd

Station Number	126	146	169	Station Number	169
23		1.7×10^{-9}	1.0×10^{-9}	45	
24			7.9×10^{-10}	46	
25	6.9×10^{-9}	Background	1.0×10^{-9}	47	
26				48	
27	6.6×10^{-9}	3.5×10^{-10}	9.9×10^{-10}	49	
28	5.7×10^{-9}	3.5×10^{-10}	6.6×10^{-10}	50	
29	5.4×10^{-9}	3.5×10^{-10}	1.5×10^{-10}	51	
30				52	
31	4.5×10^{-9}	Background	Background	53	
32	2.5×10^{-9}	Background	Background	54	
33	2.9×10^{-10}	6.6×10^{-10}	3.5×10^{-10}	55	
34	Background	6.6×10^{-10}		56	4.7×10^{-10}
35				57	4.2×10^{-10}
36				58	4.2×10^{-10}
37	Background			59	6.6×10^{-10}
38	Background	Background		60	8.0×10^{-10}
39		Background		61	6.1×10^{-10}
40	Background	Background		62	1.3×10^{-9}
41	Background	Background		63	
42	Background	Background		64	
43		Background		65	
44	4.2×10^{-10}	Background		66	1.6×10^{-9}

TABLE 1 cont'd

Station Number	126	146	169
1	1.5×10^{-9}	3.5×10^{-10}	Background
2			
3			3.5×10^{-10}
4			
5	1.7×10^{-9}	1.7×10^{-9}	1.5×10^{-10}
6			
7	2.3×10^{-9}	1.3×10^{-9}	3.5×10^{-10}
8	2.8×10^{-10}		3.5×10^{-10}
9	4.5×10^{-9}		5.6×10^{-10}
10			
11			
12			
13			
14			
15			
16		Background	
17	6.9×10^{-9}	3.5×10^{-10}	Background
18	6.6×10^{-9}	1.0×10^{-9}	3.5×10^{-10}
19	6.6×10^{-9}	1.3×10^{-9}	7.9×10^{-10}
20		1.7×10^{-9}	5.6×10^{-10}
21		1.7×10^{-9}	5.6×10^{-10}
22		1.7×10^{-9}	

TABLE 1 cont'd

Station Number	24	25	30	122	126	115
45				Background		Background
46	1.0×10^{-9}	Background	Background	1.3×10^{-10}	6.6×10^{-10}	Background
47						
48		Background	Background	5.2×10^{-10}		
49						Background
50	8.4×10^{-10}					
51	5.4×10^{-10}		Background	Background	3.5×10^{-10}	6.1×10^{-10}
52						
53						
54	8.2×10^{-9}					8.4×10^{-10}
55	8.3×10^{-9}		Background			8.9×10^{-10}
56	6.9×10^{-9}		Background	7.5×10^{-10}	1.5×10^{-9}	4.2×10^{-10}
57	2.5×10^{-10}		1.4×10^{-9}	1.0×10^{-9}	1.4×10^{-9}	7.0×10^{-10}
58	2.5×10^{-10}		6.1×10^{-10}	1.0×10^{-9}	1.4×10^{-9}	8.0×10^{-10}
59	2.1×10^{-10}		1.1×10^{-9}	1.1×10^{-9}	1.4×10^{-9}	1.2×10^{-9}
60			Background	1.6×10^{-9}		1.2×10^{-9}
61	7.9×10^{-10}		8.4×10^{-10}	1.3×10^{-9}	1.1×10^{-9}	
62			8.4×10^{-10}	1.6×10^{-9}	Background	1.8×10^{-9}
63	6.6×10^{-10}		Background		Background	
64	9.4×10^{-10}		1.6×10^{-8}	1.4×10^{-9}	Background	Background
65					Background	
66	1.7×10^{-9}				Background	

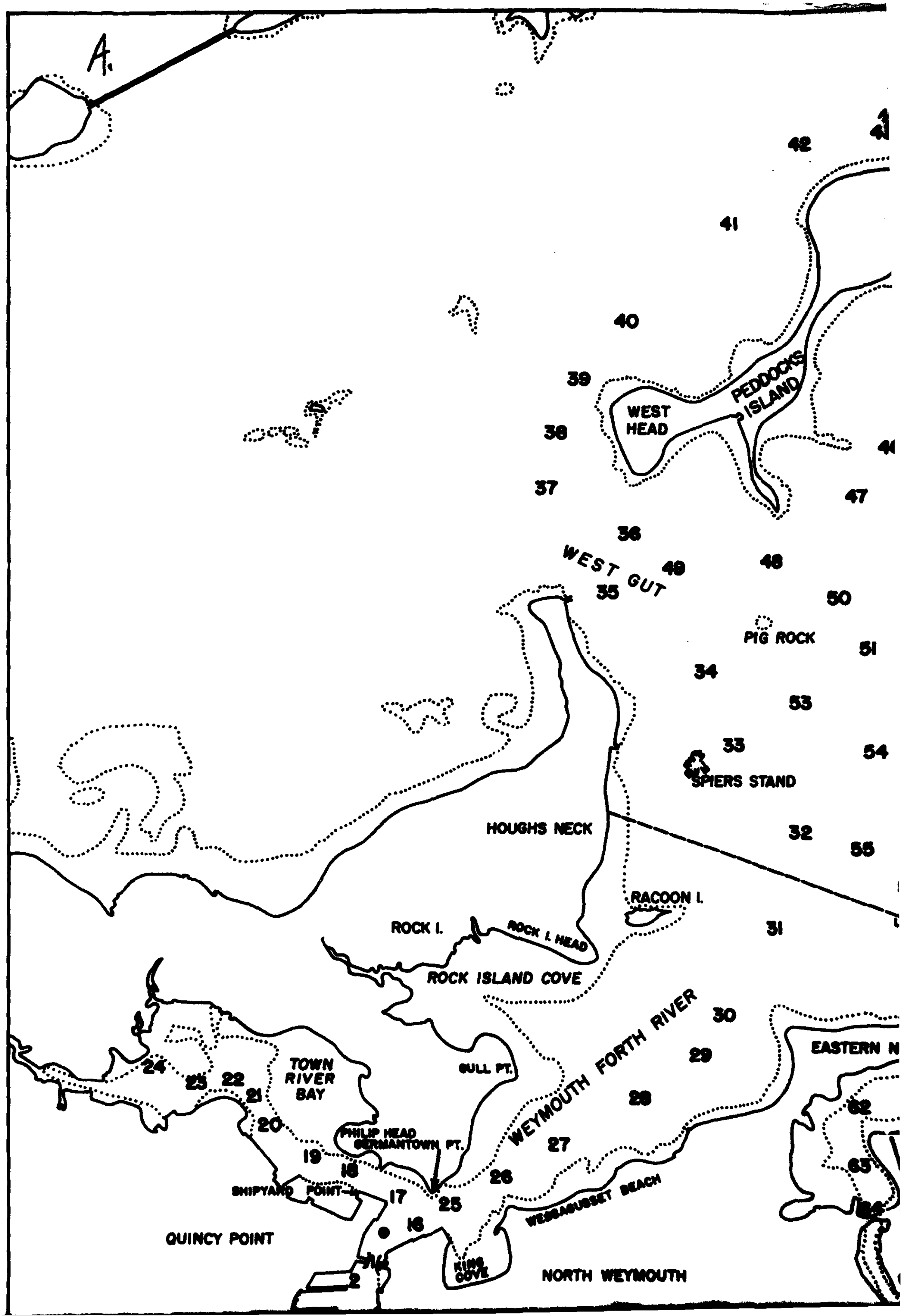
Dilution Factors for Weymouth Fore River

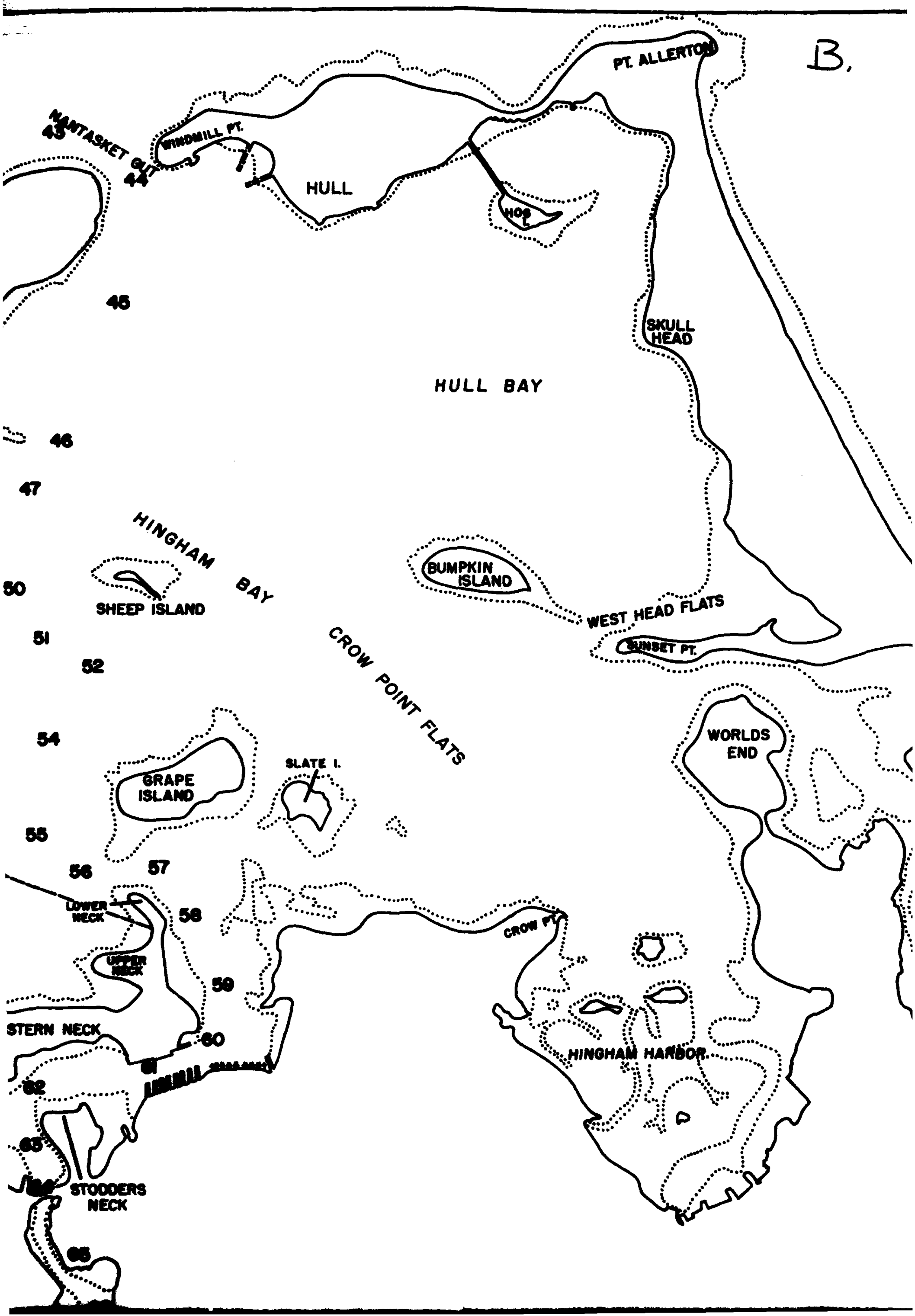
Time after release (hours)	Dilution Factors	
	/cc	/ft^3
0.5	4.2×10^{-11}	1.2×10^{-6}
1.0	2.9×10^{-11}	8.2×10^{-7}
2.0	1.8×10^{-11}	5.1×10^{-7}
4.0	1.2×10^{-11}	3.4×10^{-7}
6.0	9.5×10^{-12}	2.7×10^{-7}
8.0	7.7×10^{-12}	2.2×10^{-7}
12.0	5.7×10^{-12}	1.6×10^{-7}
24.0	2.4×10^{-12}	6.3×10^{-8}
48.0	6.2×10^{-13}	1.7×10^{-8}
72.0	3.1×10^{-13}	8.5×10^{-9}
96.0	1.5×10^{-13}	4.1×10^{-9}
120.0	7.9×10^{-14}	2.2×10^{-9}
144.0	4.2×10^{-14}	1.2×10^{-9}
168.0	2.2×10^{-14}	6.2×10^{-10}

1. Multiply the total amount of contaminant released (concentration x volume) by the dilution factor for the required time after release. This gives the concentration at that time.

2. Two dilution factors are given so that computations may be made either in terms of cc or ft^3.

3. The dilution factors are based on the assumption that the volume of contaminant is small in relation to the volume of the harbor or estuary.


A.
42
41
40
39
PEDDOCKS ISLAND
WEST HEAD
38
37
47
36
WEST GUT
49
48
35
50
PIG ROCK
51
34
53
33
54
SPIERS STAND
HOUGHS NECK
32
55
RACOON I.
ROCK I.
ROCK I. HEAD
31
ROCK ISLAND COVE
WEYMOUTH FORTH RIVER
30
29
EASTERN N
24
23
22
21
TOWN RIVER BAY
GULL PT.
28
62
20
PHILIP HEAD
GERMANTOWN PT.
27
19
18
26
63
SHIPYARD POINT
17
25
WESSAGUSSET BEACH
16
QUINCY POINT
KING COVE
NORTH WEYMOUTH
2


B.
PT. ALLERTON
NANTASKET GUT
WINDMILL PT.
HULL
HOG I.
43
44
45
HULL BAY
SKULL HEAD
46
47
HINGHAM BAY
50
SHEEP ISLAND
BUMPKIN ISLAND
WEST HEAD FLATS
SUNSET PT.
51
52
CROW POINT FLATS
54
WORLDS END
SLATE I.
GRAPE ISLAND
55
56
57
LOWER NECK
58
UPPER NECK
CROW PT.
59
STERN NECK
60
61
HINGHAM HARBOR
62
63
64
STODDERS NECK
65

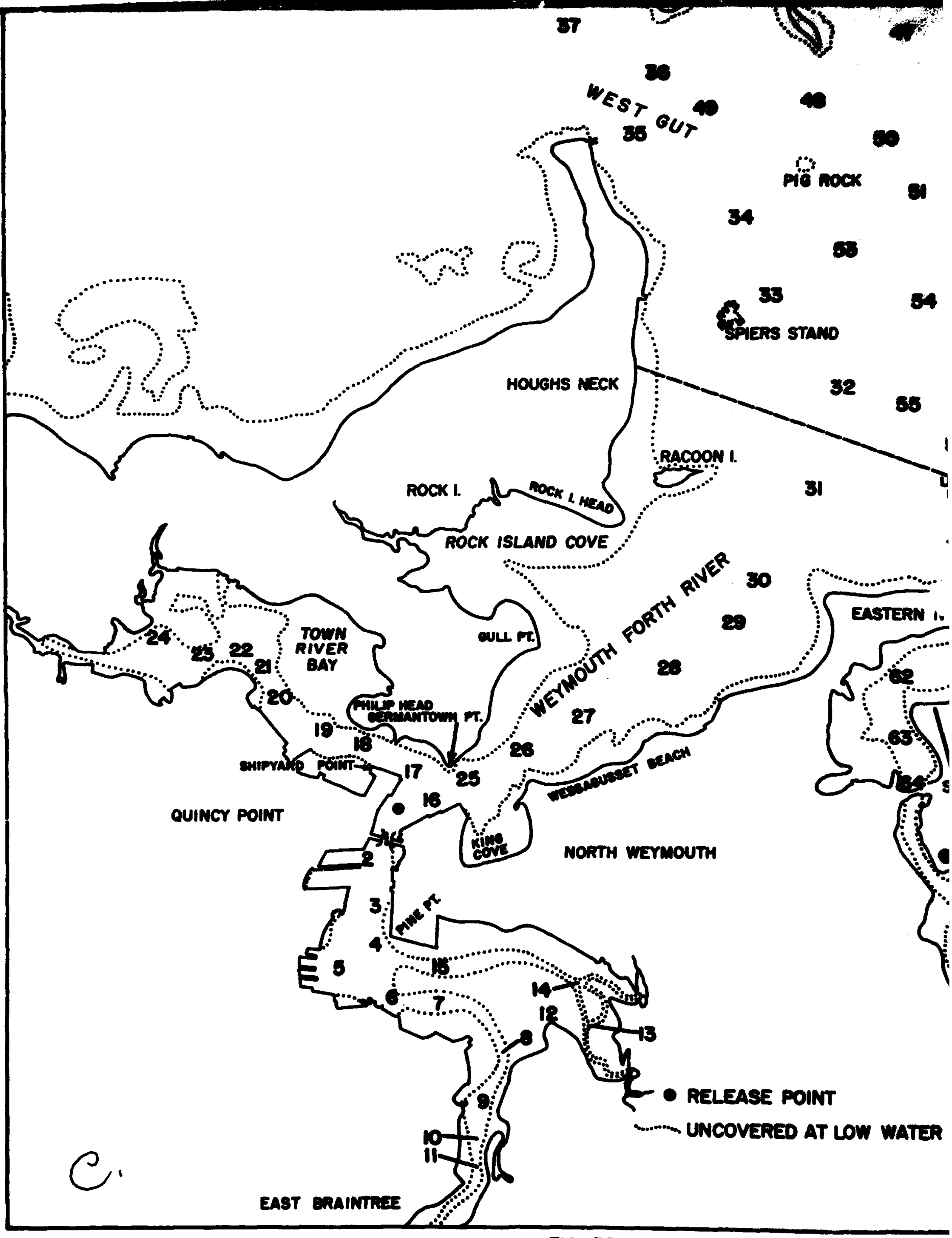
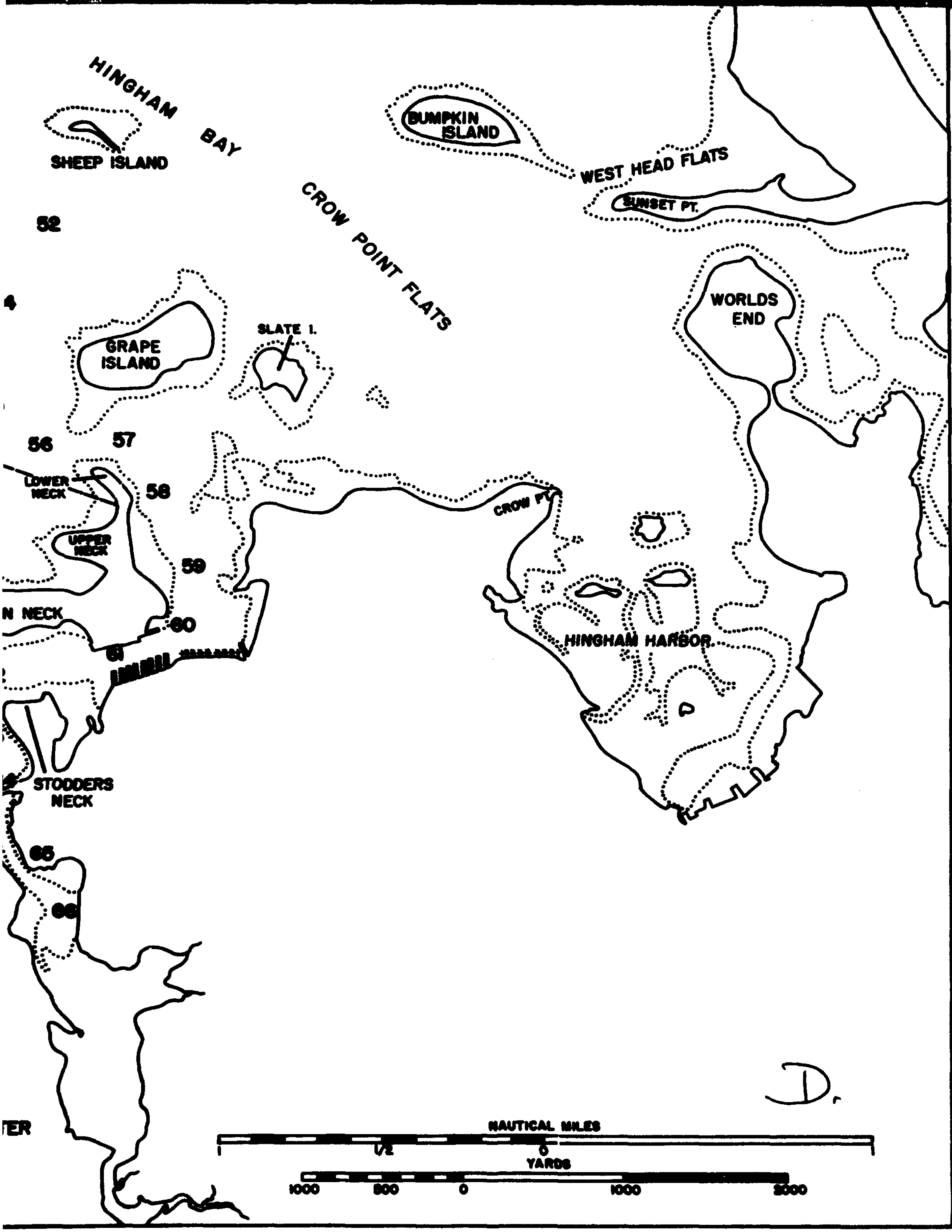


FIGURE I. STATION LOCATOR CHART—WE



WEYMOUTH FORE RIVER AND VICINITY

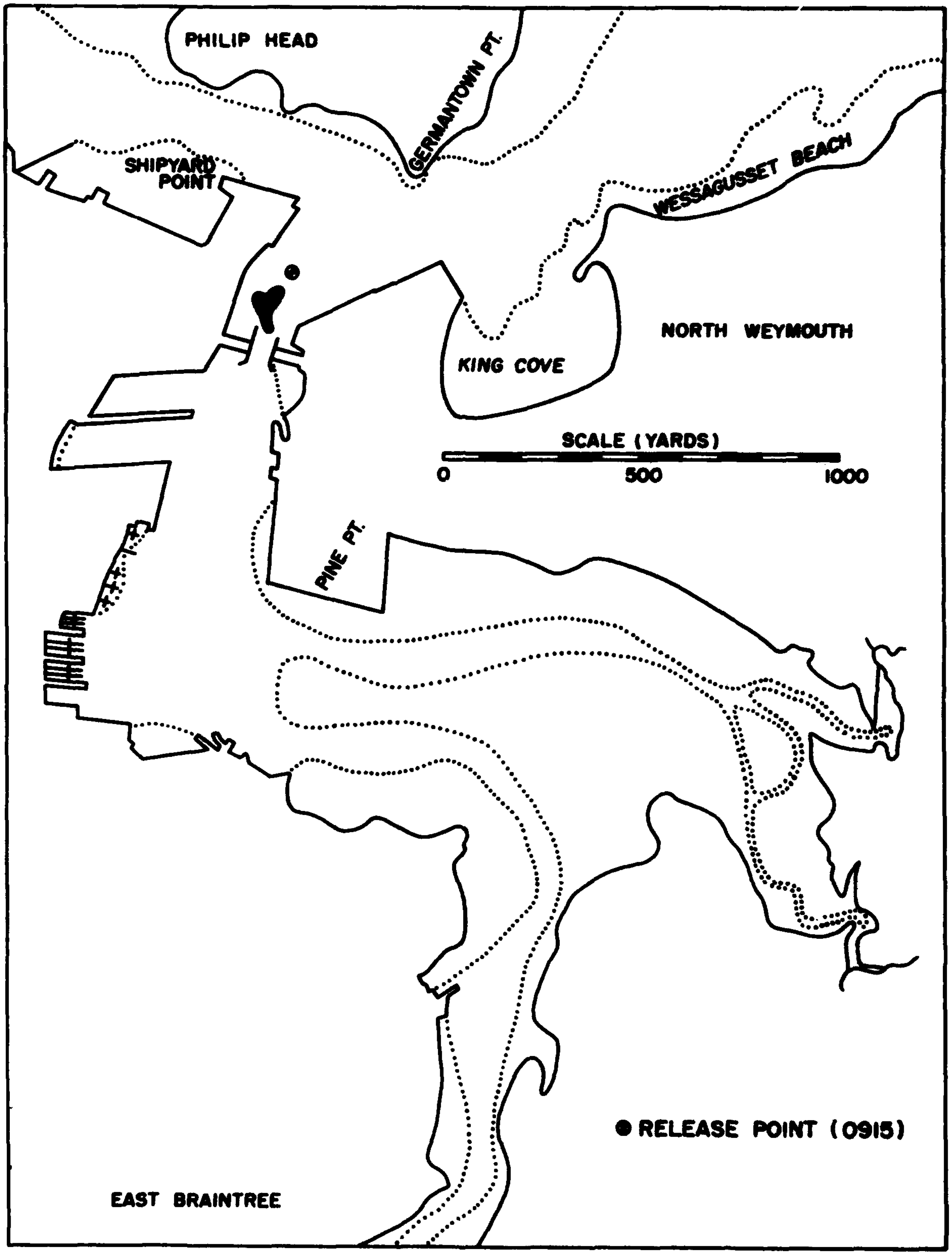


FIGURE 2. POSITION OF DYE PATCH 10 MINUTES AFTER RELEASE (0915)

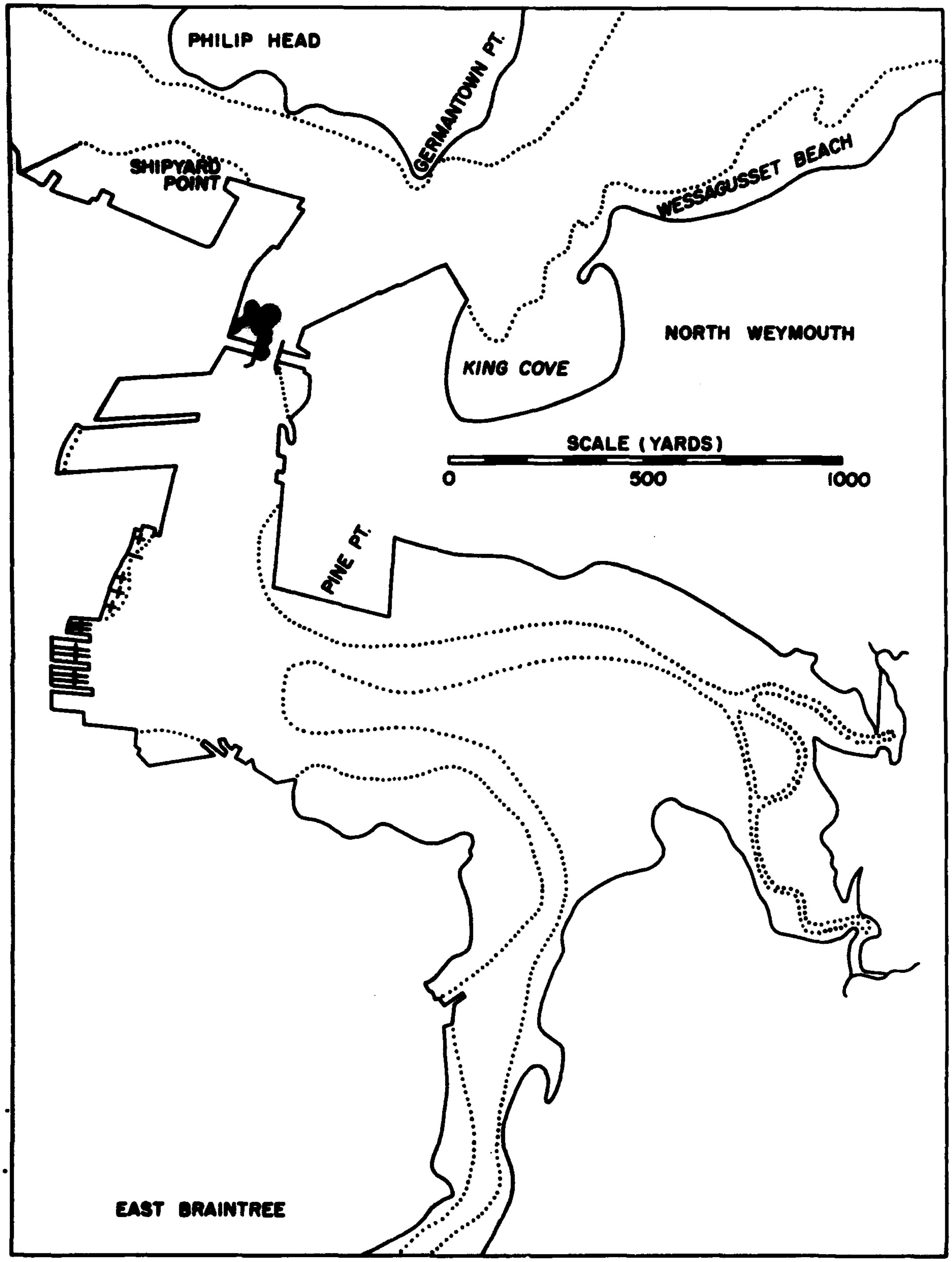


FIGURE 3. POSITION OF DYE PATCH 15 MINUTES AFTER RELEASE (0915)

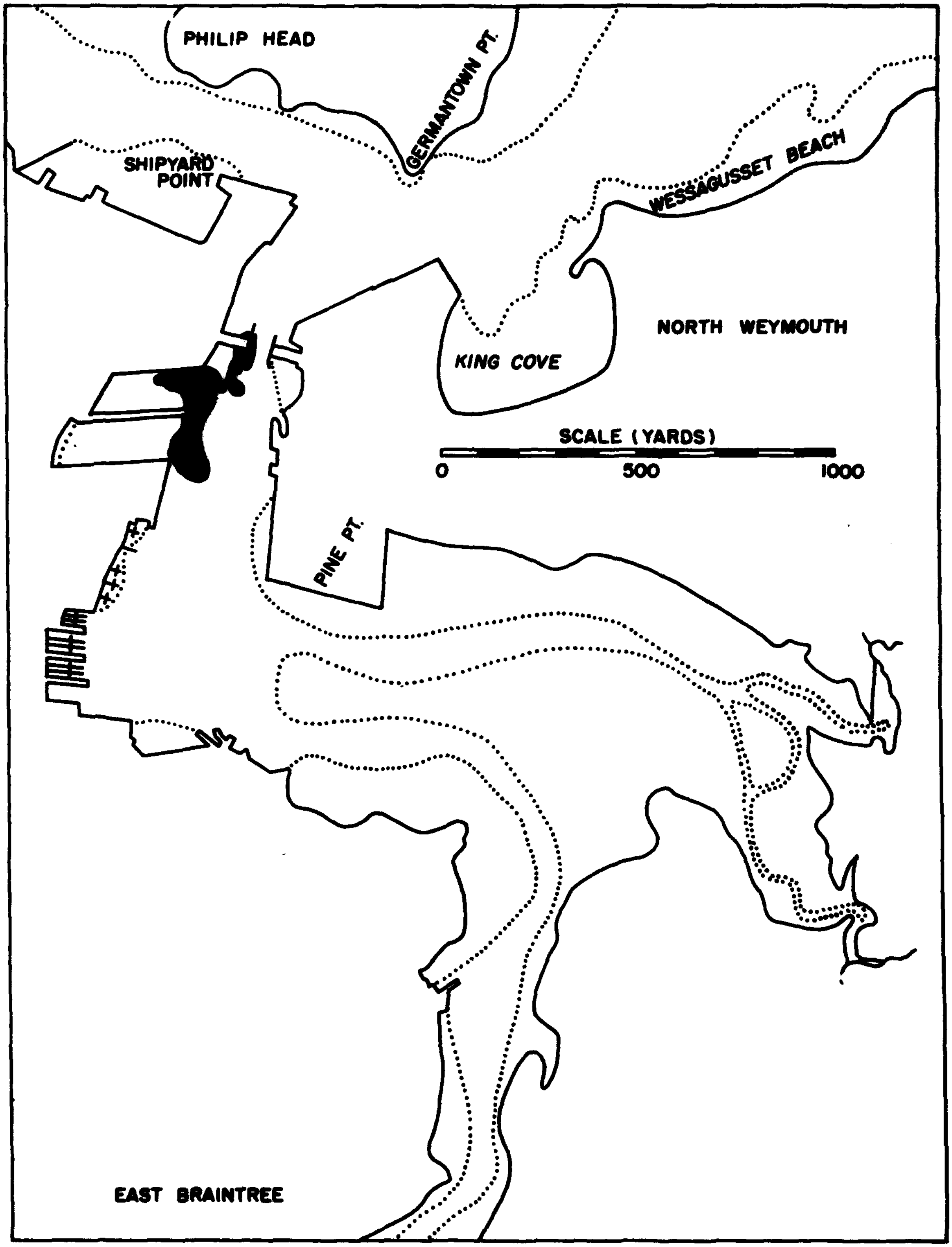


FIGURE 4. POSITION OF DYE PATCH 45 MINUTES AFTER RELEASE (0915)

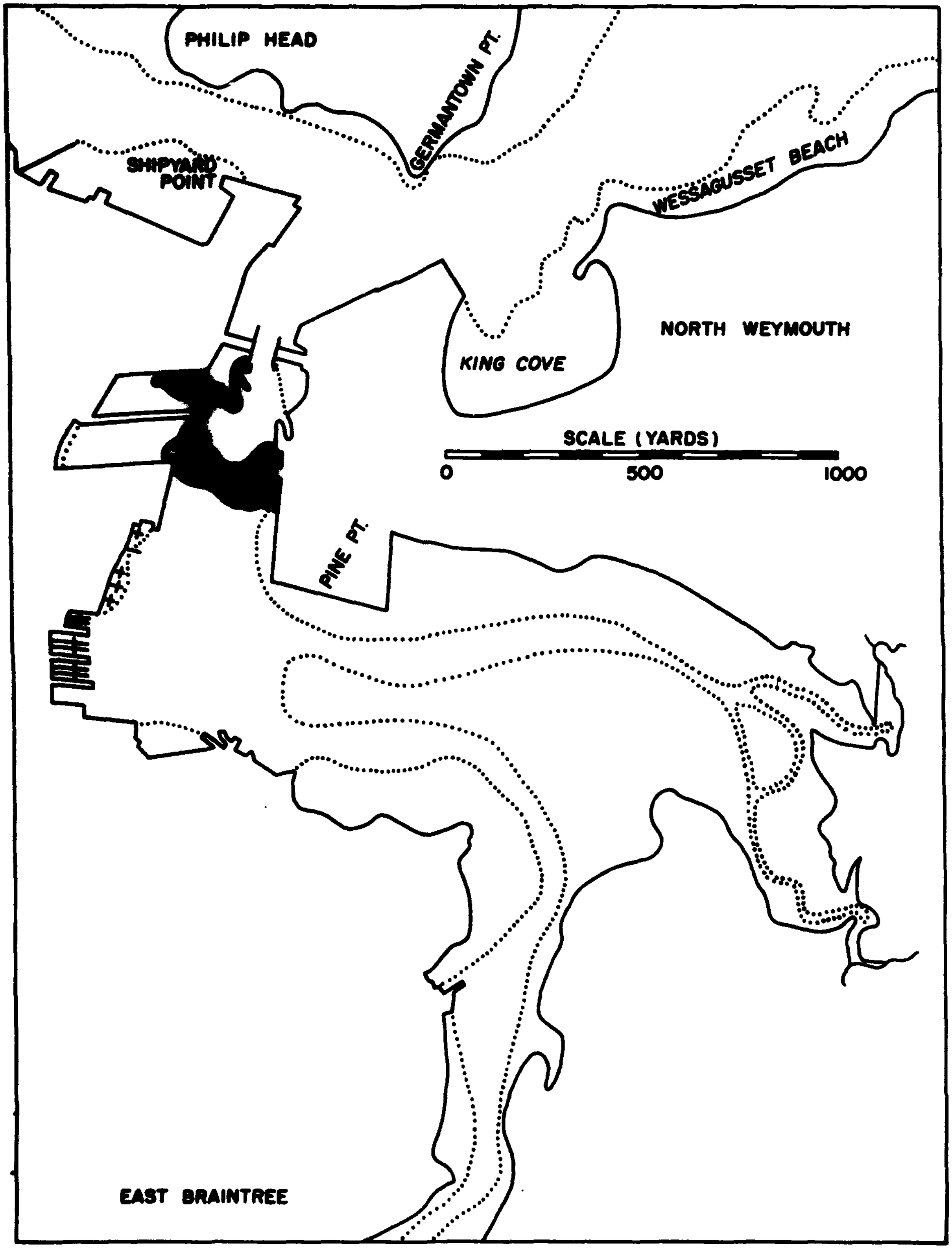


FIGURE 5. POSITION OF DYE PATCH 1 HOUR 15 MINUTES AFTER RELEASE (0915)

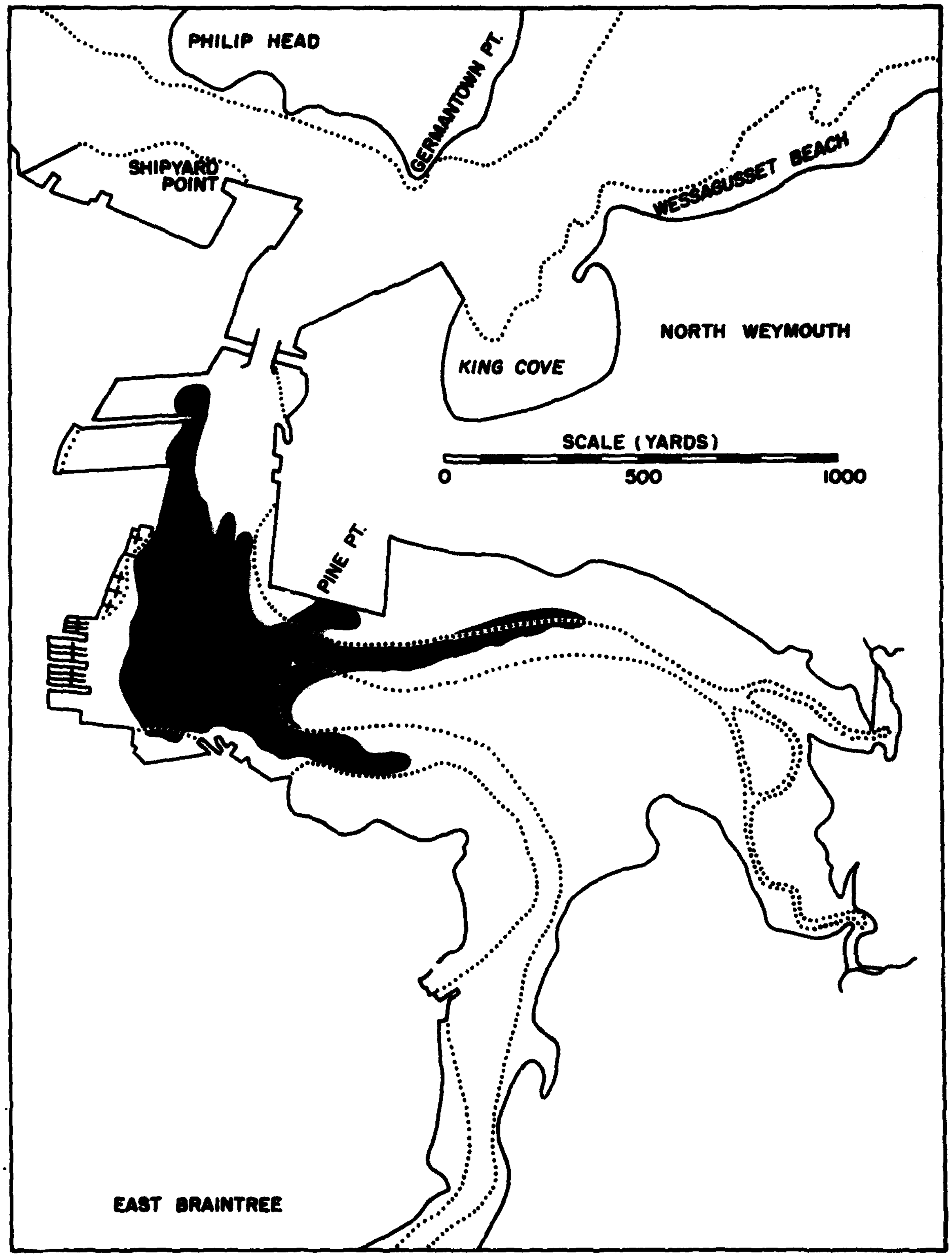


FIGURE 6. POSITION OF DYE PATCH 1 HOUR 45 MINUTES AFTER RELEASE (0915)

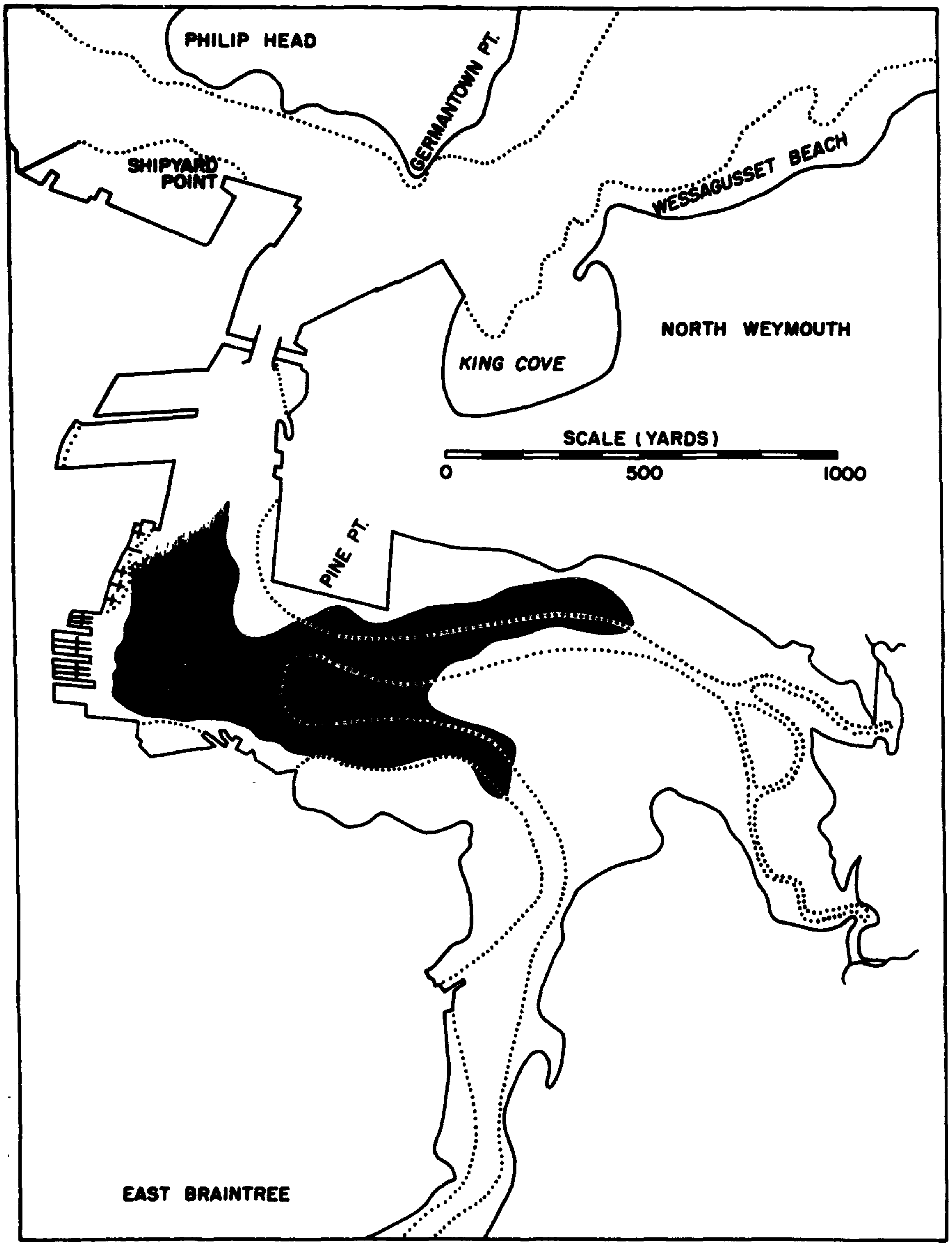


FIGURE 7. POSITION OF DYE PATCH 2 HOURS 15 MINUTES AFTER RELEASE (0915)

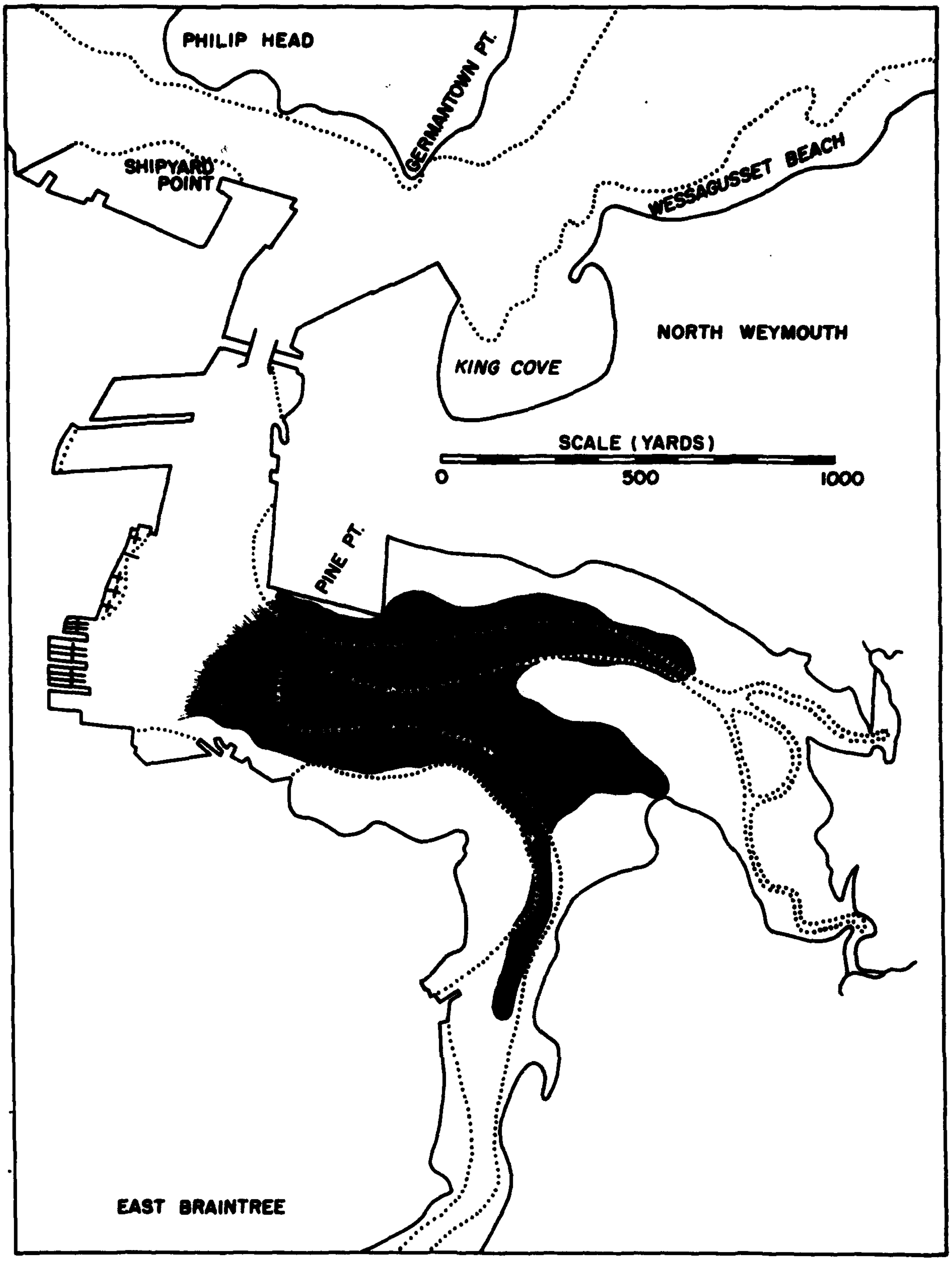


FIGURE 8. POSITION OF DYE PATCH 3 HOURS 15 MINUTES AFTER RELEASE (0915)

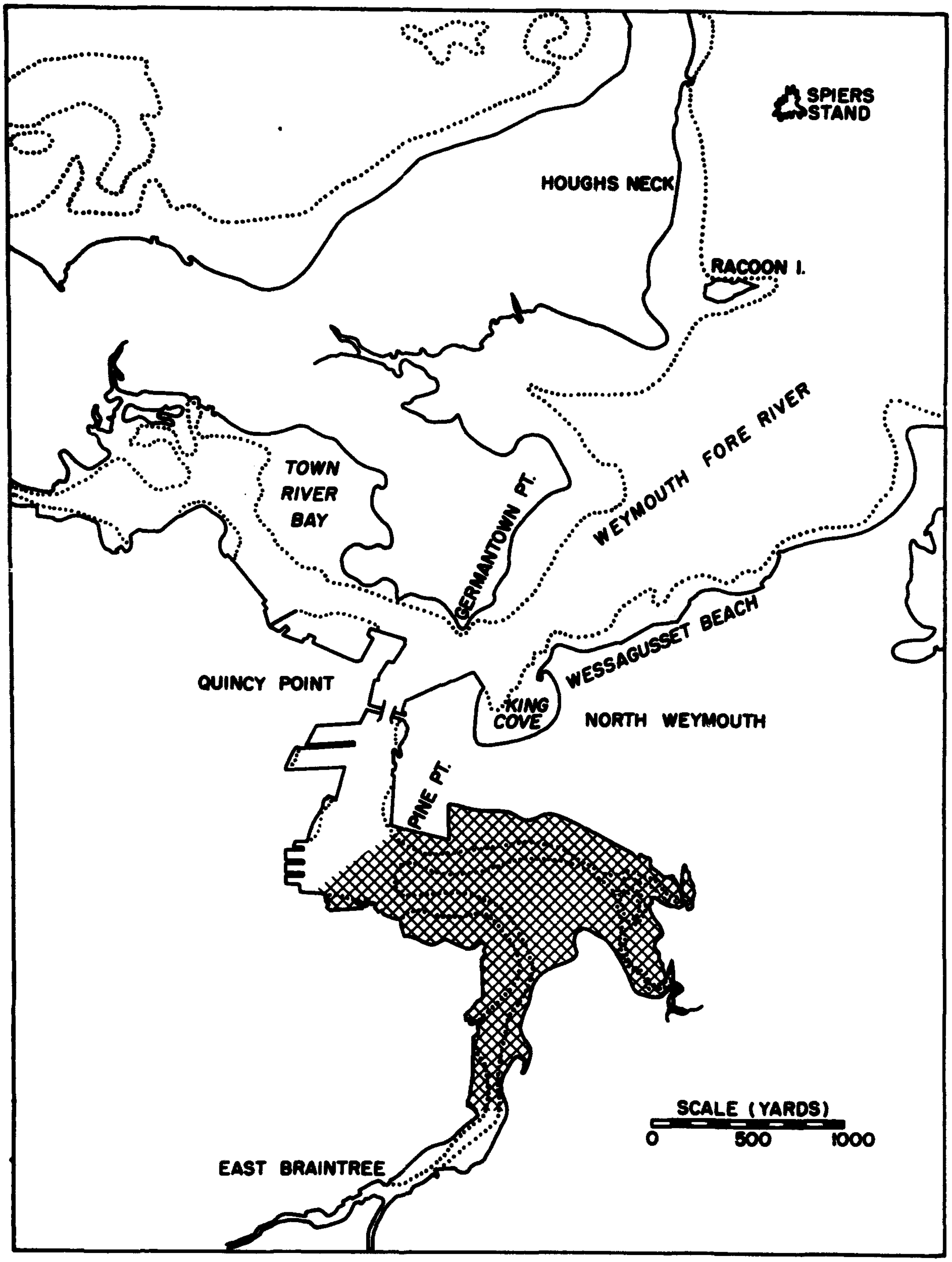


FIGURE 9. REGION OF MAJOR DYE ENTRAPMENT

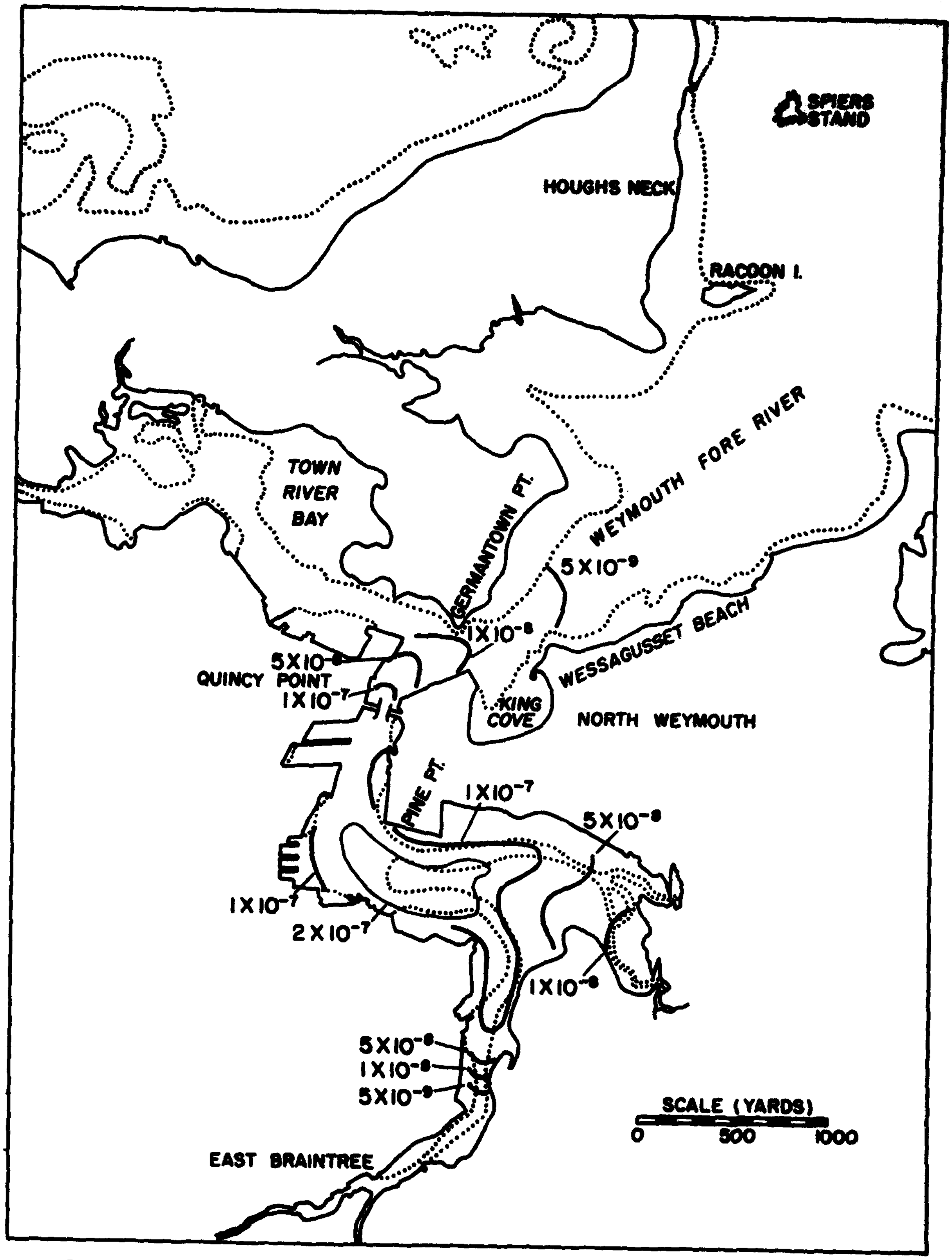


FIGURE 10. DYE DISTRIBUTION (G/CC) 6 HOURS AFTER RELEASE (0915)

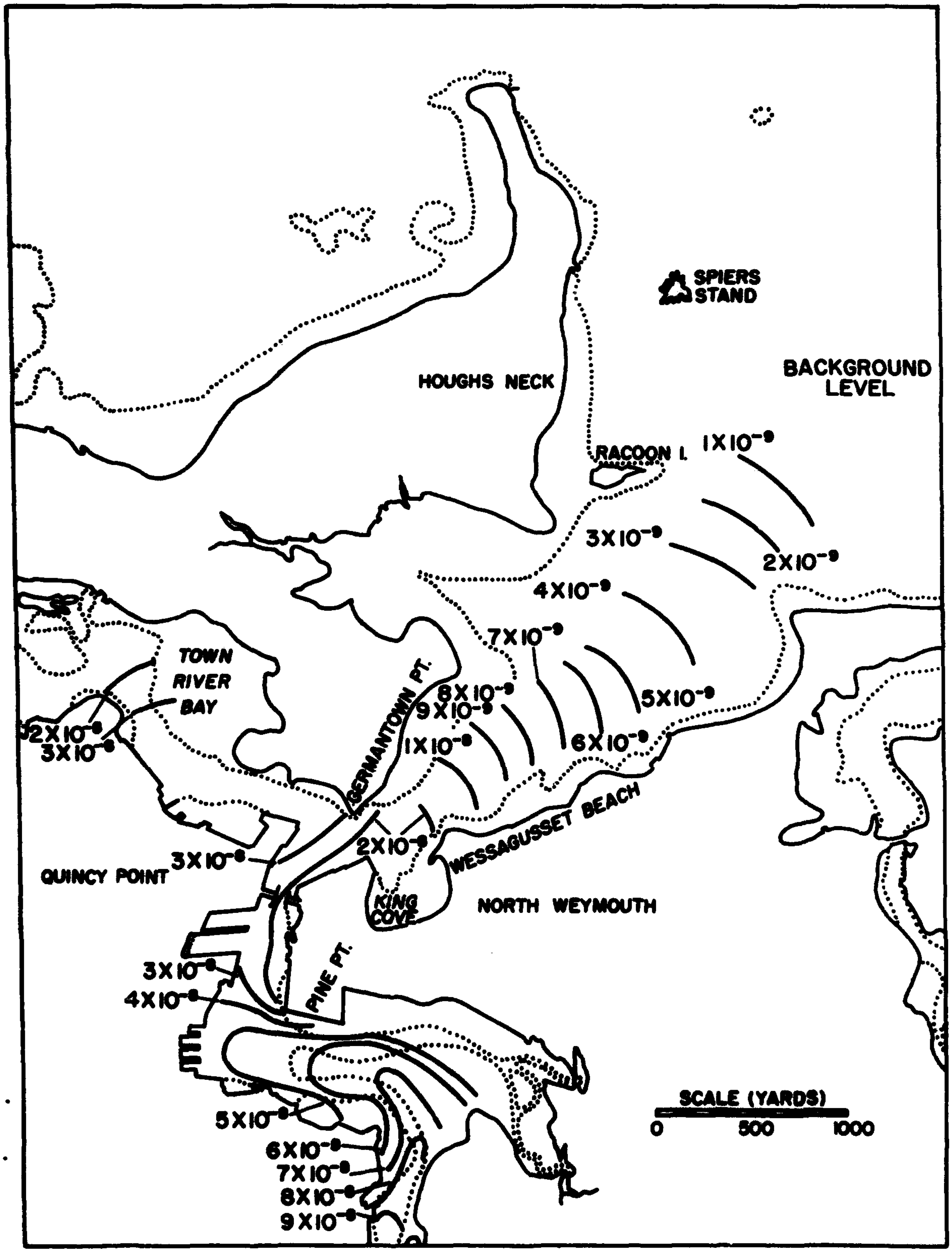


FIGURE 11. DYE DISTRIBUTION (G/CC) 30 HOURS AFTER RELEASE (0915)

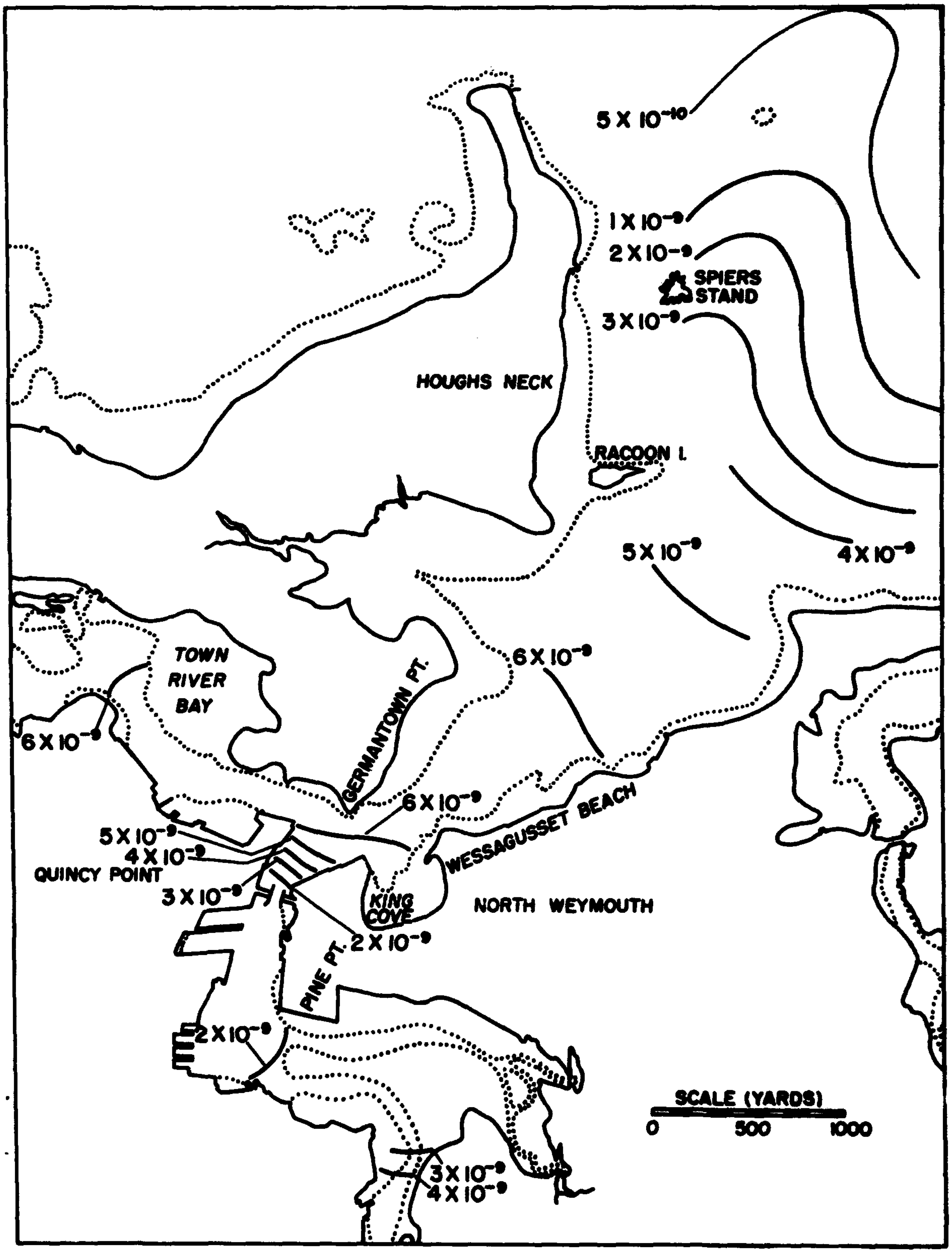


FIGURE 12. DYE DISTRIBUTION (G/CC) 126 HOURS AFTER RELEASE (0915)

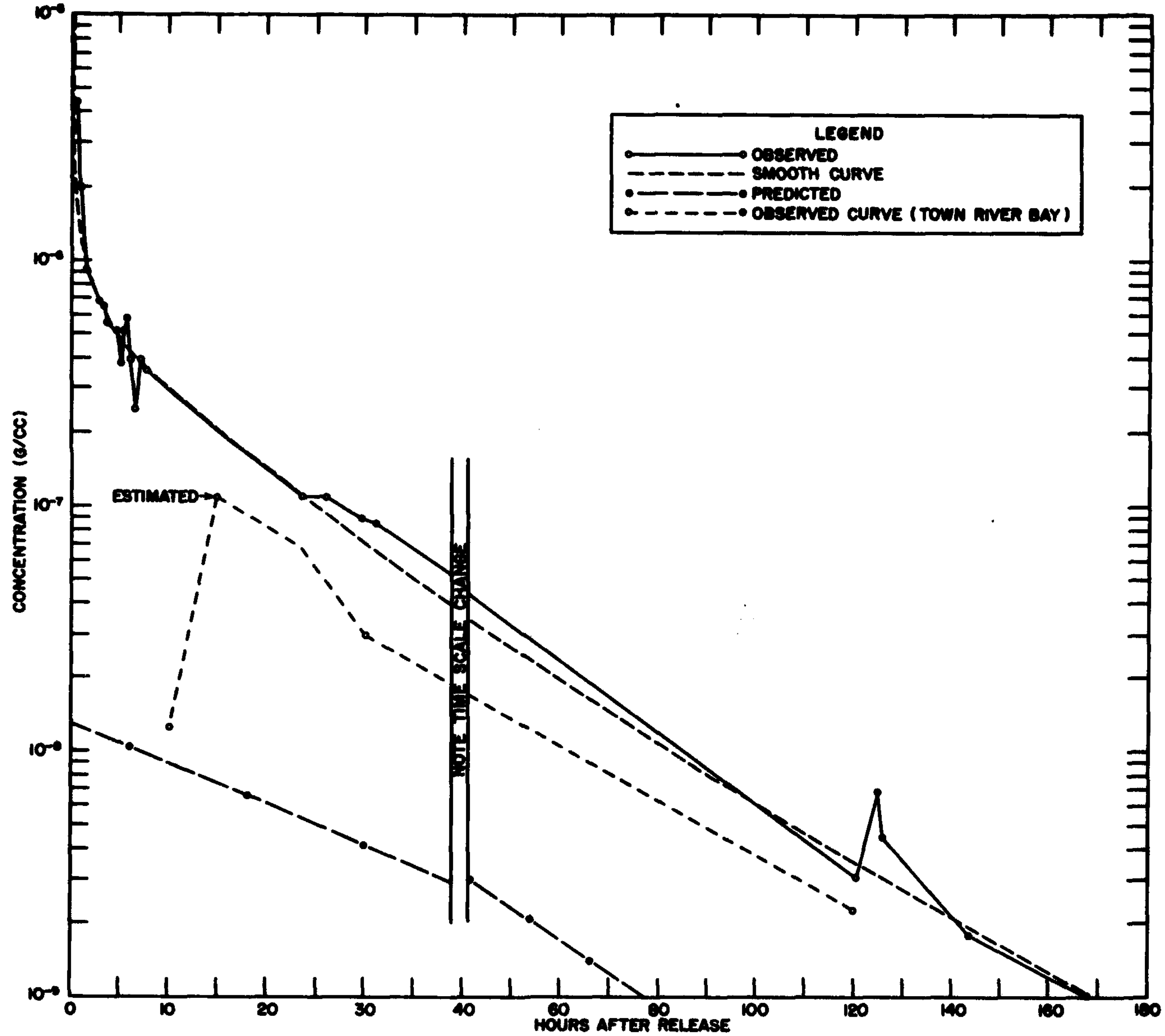


FIGURE 13. COMPARISON OF PREDICTED AND OBSERVED DECREASE OF PEAK CONCENTRATION